

ENSURING THE INTEGRITY OF POSSIBLE MARTIAN LIFE

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As we expand our presence in the solar system and beyond, novel and challenging scientific, mission planning, and policy issues will face us. A relatively near-term issue requiring attention involves the in situ human search for and potential discovery of primitive extraterrestrial life—Mars being an obvious candidate. While there has been substantial work regarding forward contamination with respect to robotic missions, the issue of potential adverse effects on possible indigenous Martian ecosystems due to a human mission has remained relatively unexplored and may require our attention now as this paper will try to demonstrate by exploring some of the relevant scientific questions, mission planning challenges, and policy issues. An informal, high-level mission planning decision tree will be discussed.

Some of the questions to be considered are: To what extent could contamination due to a human presence compromise possible indigenous life forms? To what extent can we control contamination? For example, will it be local or global? What are the criteria for assessing the biological status of Mars, both regionally and globally? For example, can we adequately extrapolate from a few strategic missions? What should our policies be regarding our mission planning and possible interaction with primitive forms of extraterrestrial life?

Central to the science and mission planning issues is the role and applicability of terrestrial analogs and modeling techniques. Central to many of the policy aspects are scientific value, international law, public concern, and ethics. Exploring this overall issue responsibly requires an examination of all these aspects and how they interrelate.

INTRODUCTION

The primary focus of this paper will be on potential adverse effects to possible indigenous life-forms due to a human mission to Mars. Three broad reasons for addressing this issue are international law, scientific value, and public interest. Article IX of the United Nations Outer Space Treaty of 1967 states that State Parties should avoid harmful contamination of the moon and other celestial bodies.¹ In 1983, after having gathered more data about Mars and the solar system, NASA moved away from the previous probabilistic standards for planetary protection procedures and adopted a less rigid policy involving five categories of missions and associated planetary protection requirements. There is no category

addressing human missions. This may be because it is thought that once a human mission is underway, forward planetary protection will not be relevant.² Also, human missions to the planets are not a near-term priority. However, this paper will indicate that such a category may be required sooner than later.

Although the preservation of extraterrestrial environments is important for scientific knowledge in general, a primary concern of planetary protection is to ensure the integrity of life-detection experiments by minimizing the chance of a false-positive result.³

1. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Jan 27, 1967, 18 U.S.T. 2410

2. Chris McKay and Wanda Davis write: "It is arguable that once humans land on Mars, attempts to maintain a strict policy of preventing the introduction of Earth life into the martian environment will become moot." Planetary Protection Issues in Advance of Human Exploration of Mars, *Advanced Space Research* Vol. 9, No. 6, p. 197 (1989).

3. Darlene Cypser argues convincingly that "harmful contamination to other states" (that which is to be avoided as

Underlying these concerns is the widely acknowledged importance of discovering the “second data point” that biology is so desperate for. The National Academy of Sciences Space Science Board writes: “Forward contamination is a significant threat to interpretation of results of in situ experiments specifically designed to search for evidence of extant or fossil martian microorganisms”, and that protecting Mars from terrestrial contamination so as to not jeopardize future life-detection experiments is “profoundly important”.⁴

However, some suggest that contamination concerns are misguided. There are at least three kinds of arguments. One, Mars and Earth have exchanged much material already. Two, the co-evolutionary dependence of pathogens and hosts makes it impossible for Martian and terrestrial organisms to adversely affect each other.⁵ Three, life almost certainly does not, and cannot, exist on the Martian surface. Unfortunately, it may not be that simple. The fact that material has been exchanged between our planets does not mean that contamination has occurred in the way it could with a sustained and significantly more intrusive human presence on Mars. If panspermia has occurred, then Martian organisms could be genetically compatible with new organisms that arrive via contamination, calling into question the claim that a lack of co-evolutionary dependence should mitigate contamination concerns. Also, *indirect* adverse effects could be important as will be discussed later. Lastly, the lack of existence of life on the surface cannot be known with sufficient confidence until we conduct more missions. While life on Mars may be improbable, we should not underestimate how unpredictable, and possibly life-bearing, our solar system might be. Terrestrial extremophiles and potentially life-bearing features of other solar system bodies justify this caution.

Even if we were to confirm that no life exists on the surface of Mars, there is the possibility of subsurface life—which should still be of great concern since our intrusive missions could contaminate the subsurface

of Mars via drilling and other activities.⁶ Surface or subsurface life could also be adversely affected by toxic substances, predation, competition, and general environmental modifications.⁷ Lastly, we only understand one kind of biology. How confident can we be that life on Mars will be consistent with our present understanding of life when we really only have one example?

There is also the issue of anticipating and addressing public concern. As there have been in the past, there will be public interest groups attempting to ensure that NASA and other space agencies are not only doing what is perceived to be environmentally correct, but perhaps morally correct as well. Species preservation groups will have a new cause to champion, and it should be assumed that they will not hesitate to act as an obstacle if they have reason to believe proper precautions are not being implemented.⁸

MISSION PLANNING FOR PRESERVING POSSIBLE MARTIAN LIFE

Figure 2-1, Mission Planning Decision Tree for Preserving Possible Martian Life From Effects of Human Mission, is a preliminary attempt, via an informal decision tree, to frame the issues regarding mitigating adverse effects of a human presence on Mars. An underlying assumption of the decision tree is that the scientific value of preserving extraterrestrial life is high enough that many would agree that these questions are worth pursuing, and possibly high enough to justify a fairly conservative mission planning approach as indicated by the decision tree. This section will step through the decision tree and provide rough preliminary thoughts to most of the key questions.

called for by the Outer Space Treaty) can best be interpreted to mean interference with future life-detection experiments. Darlene A. Cypser, International Law & Policy of Extraterrestrial Planetary Protection, *Jurimetrics* Vol 33, p. 324-325, 338. (1993).

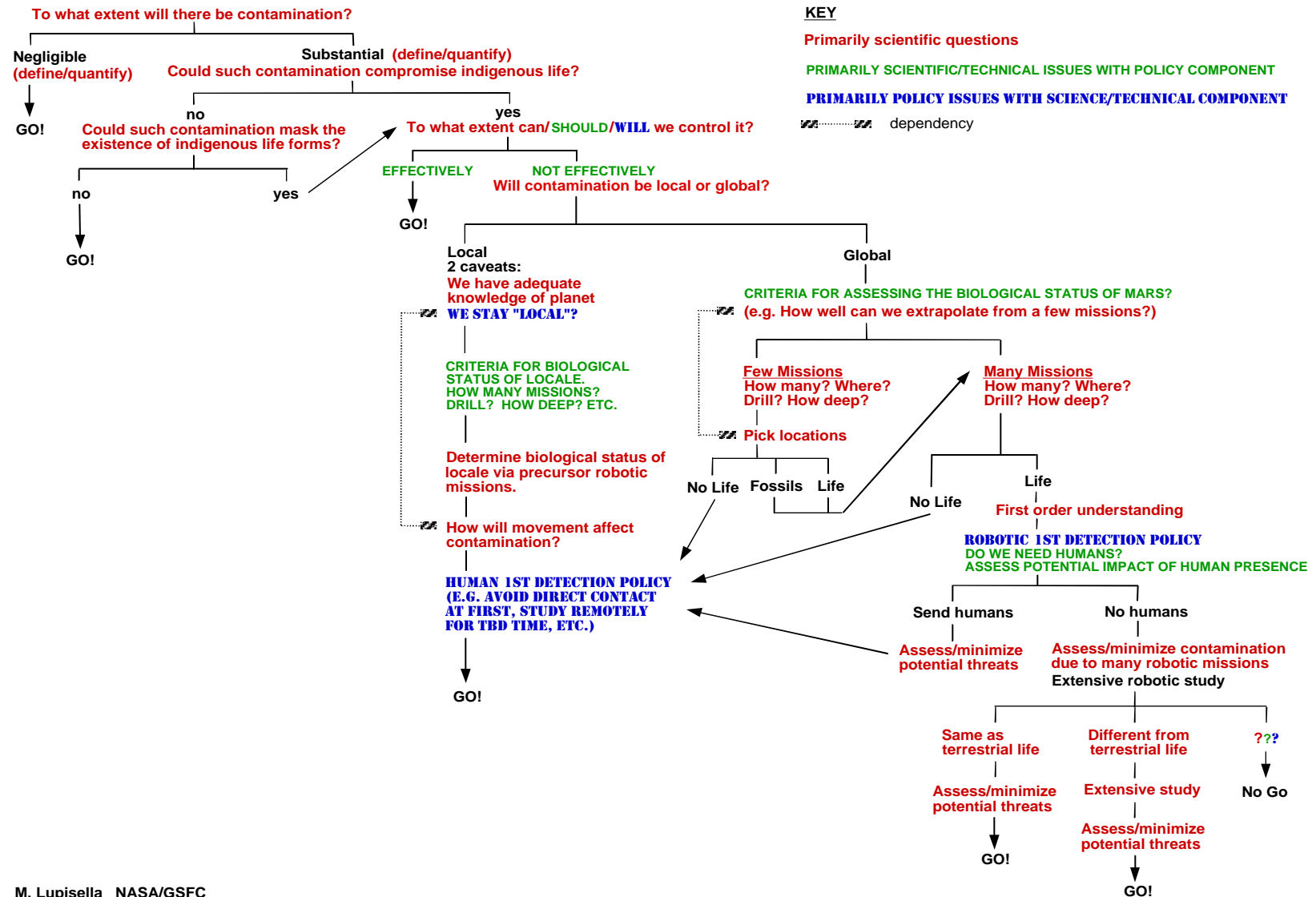
4. Space Studies Board, National Research Council, *Biological Contamination of Mars: Issues and Recommendations*. National Academy Press, Washington, D.C., p. 47, 49 (1992).
5. Robert Zubrin and Richard Wagner, *The Case For Mars*, New York, Simon and Schuster, pp. 132-134, (1996). T. H. Jukes makes the case for pathogenic coevolutionary dependence in his paper, Evolution and Back Contamination, *Life Sciences and Space Research* XV, 9 (1977).

6. Prior to the Apollo missions, the Space Studies Board recommended a sterile drilling system. M. Werber, Objectives and Models of the Planetary Quarantine Program 13, NASA SP-344, Sup. Doc. No. NAS 1.21:344 (1974). Also, subsurface drilling on Earth has raised concern about whether organisms brought to the surface are indeed indigenous to the subsurface or whether they were transported there from the surface. A recent National Science Foundation Workshop on Lake Vostok, a sub-glacial lake in Antarctica, focused heavily on contamination issues regarding drilling activities.

7. McKay and Davis note several sources of environmental impacts due to a human base that should be considered, including mechanical disturbances, life support system leakage, airborne pollution, and “seemingly innocuous perturbations” like water, heat, light, etc. P. 198.

8. For an analysis of social factors see: Margaret S. Race, Societal Issues as Mars Missions Impediments: Planetary Protection and Contamination Concerns. *Advanced Space Research* Vol 15, p. 285 (1994).

Figure 2-1: Mission Planning Decision Tree for Preserving Possible Martian Life From Effects of a Human Mission



To what extent will there be contamination? Chris McKay and Wanda Davis suggest that contamination is inevitable if humans are present.⁹ But we should try to establish the extent, preferably quantitatively, to which there will be contamination since the amount and kind will likely be critical to mission planning. If contamination possibilities are thought to be negligible, a human mission should not be prevented from occurring as soon as possible.

If it is thought that there could be contamination to levels that are deemed significant, we should then ask: ***Could such contamination compromise indigenous life-forms?*** A conservative answer to the question is yes, it is possible. But again, this requires substantial analysis and research. What is the probability? Is it even feasible to establish such probabilities with any confidence? What kinds of effects could there be and to what degree? We might want to assess the relative probabilities of direct adverse effects given panspermia vs. a separate origin. Is the latter a probability of zero? The Space Studies Board says no.¹⁰ What are the chances for indirect adverse effects via toxins or competition for resources? Could non-biological elements such as rocket exhaust or industrial chemicals compromise indigenous ecosystems? Given that a single kind of life-form might have caused the extinction of all others early on in the evolution of life on earth, could a similar scenario occur if foreign organisms are brought to Mars?¹¹ If we obtain an appropriate level of confidence that contamination will not adversely effect possible indigenous life, then GO!

Otherwise, we should ask: ***Could contamination mask the existence of indigenous life-forms?*** A masking effect will presumably depend on whether the contaminating organisms are dead or viable, either as dormant or active organisms. Dead organisms should not have a significant masking effect for life-detection experiments based on life processes such as metabolism. However, dead organisms might have a masking effect for simple observation based detection devices such as microscopes and robotic life-detection devices—although, presumably, with humans

present, detailed analysis could be done that should mitigate this problem. While perhaps not the most likely scenario, we might consider that dead terrestrial organisms, after having been on Mars for some time, will not be recognizable as terrestrial organisms. For example, there might only remain fragments of organisms, or the organisms might undergo physical modification, making it difficult, if not impossible, to rule out an indigenous source.¹² It may also be very difficult to determine if the resident organisms were deposited by the mission or whether they arrived via panspermia—an important scientific question in its own right. If we're confident that masking effects are not significant, then GO!

However, if we determine there is an unacceptable chance of masking possible indigenous life, we should ask: ***To what extent can/should/will we control contamination?*** The “should” and “will” part of this question are both important for a realistic assessment of the outcome of this decision point. That is, we may determine that we *can* control contamination effectively, but that perhaps, for various reasons, we shouldn't; and even if we think we should, an honest assessment would include considering that other forces could prevail, resulting in compromising contamination control. Whether or not we *will* actually control contamination is a legitimate and important question because we often don't do what we think we should do. It is reasonable to suspect that many people who suggest we should control contamination, will also think that, ultimately, our selfish, exploitive, and destructive, tendencies will likely prevail.¹³

Joseph Sharp has suggested that absolute containment of all terrestrial biology is, in principle, possible and even desirable over the less certain method of obtaining all other relevant data to determine that contamination will not cause adverse effects. Sharp points out that an entire technology has been developed to contain dangerous biological

9. McKay and Davis write: “It may be assumed, a priori, that all space suits and habitats will leak.” P. 197. This is known to have been the case with Apollo since it is thought that there was “significant leakage of gases from the joints of the astronauts’ suits”. Victor Cohn, Lunar Contamination: Growing Worry, *Washington Post*, 28 May 1969, p. A12.

10. Space Studies Board, National Research Council, *Mars Sample Return Report*. p. 2 (1997).

11. Freeman Dyson brought this terrestrial analog to my attention in a personal communication. (August 1998).

12. The Space Science Board writes “Contamination with terrestrial material would compromise the integrity of the sample by adding confusing background to potential discoveries related to extinct or extant life on Mars. DNA and proteins of terrestrial origin could likely be unambiguously identified, but other organic material might not be so easily distinguished. The search for candidate martian organic biomarkers would be confounded by the presence of terrestrial material. Because the detection of life or evidence of prebiotic chemistry is a key objective of Mars exploration, considerable effort to avoid such contamination is justified.” Space Studies Board (SSB), National Research Council, *Mars Sample Return Report*. pp. 37-38 (1997).

13. Indeed, many personal conversations with average laypersons, scientists, and senior NASA managers bear this out.

agents, and that while such an effort for the first human Mars mission would be quite expensive, in the long run, it may be the only sure approach as long as no failures occur.¹⁴ However, given the expense and stringent requirements of such an approach, it makes sense to consider the more realistic suggestion made by McKay and Davis that contamination is likely if humans establish a presence on Mars.

Understanding the amounts and kinds of contamination that are released into the Martian environment will be important for dealing with this overall issue.¹⁵ Will we be able to completely isolate a given locale for which contamination controls could be quite loose? Or will we want, or be able, to rigorously contain contamination for all areas and activities? If we're confident about contamination control, then GO!

If not, **will contamination be local or global?** Biological contaminants such as human bacteria may not survive Martian oxidizing surface conditions and ultraviolet radiation exposure. However, it should be noted that there is experimental evidence for some terrestrial bacteria surviving substantially higher levels of oxidant than are thought to be on Mars.¹⁶ However, we should consider that dead or viable organisms could potentially be distributed over a significant area, perhaps globally, since large, sometimes global, dust storms are known to occur.¹⁷ The likely non-viability, and hence insignificant spread of contaminant organisms on the surface, while reasonable as a first order assessment, should be analyzed with as much rigor as possible, paying

close attention to the *continuous* source of contamination due to a human presence, possibilities of subsurface contamination, and other sources of contamination. As the decision tree indicates, the local vs. global possibility of contamination is a key planning decision issue because it could mean the difference between few or many precursor missions.

If it is thought that contamination will be local, **what are the criteria for determining the biological status of a designated locale?** It may be prudent to assume that contaminants will at least be present and possibly viable over a designated locale where humans first land; so it will be important to understand what will be required to obtain confidence about the biological status of the locale in question. Robotic precursor missions and possibly tele-robotic missions from an on-orbit station or moon to a potential landing site are obvious ways to remotely obtain knowledge about the biological status of the location. *The interesting challenge is to assess what level of confidence we require and what kinds and number of missions will be needed to obtain that confidence.* Understanding subsurface possibilities will be critical since a human landing site will likely result in contamination of the top few meters, if not more, of the soil.¹⁸ We should also keep in mind that a human base will probably have the ability to drill to considerable depths below the surface (possibly to or below the permafrost level) for both exploratory and resource prospecting reasons (e.g. searching for water), which could possibly result in contamination of an otherwise protected subsurface environmental niche.

A Human First Detection Policy regarding the search for and potential interaction with extraterrestrial life-forms will also be important. We may not have the luxury of time to respond to a human in situ discovery. There will be momentum, political and otherwise, some of which is emerging now, which could be hard to curtail, especially once humans are there. Perhaps most importantly, with humans on the scene, it will be prudent to at least establish in advance appropriate decision making mechanisms, presumably of an international nature, to deal with pre and post-detection activities.

Pre-detection guidelines might address issues such as contamination control procedures, surveillance procedures before entering an area, guidelines for movement in an area, procedures for digging, drilling, waste control, etc. Such guidelines for pre-detection activities may help preserve key environments where life could exist undetected. If

14. J. C. Sharp, Manned Mars Missions and Planetary Quarantine Considerations, *Manned Mars Missions*, NASA M002, NASA Washington, D.C., p. 553, (June 1986).

15. The Apollo program made some attempts to reduce and inventory contamination. For example, a bacterial filter system on the lunar module was used to prevent contamination of the lunar surface when the cabin atmosphere was released. National Aeronautics and Space Administration, 12 May 1969, *Apollo Spacecraft Cleaning and Housekeeping Procedures Manual*, MSC-000 10, p. 3. NASA also adopted, as official policy, aseptic subsurface drilling, decontamination and contained storage of waste materials, and biological and organic material inventory requirements. National Aeronautics and Space Administration, 12 May 1969, *Outbound Lunar Biological and Organic Contamination Control: Policy and Responsibility*, Washington, D.C., NASA Policy Directive 8020.8A.

16. R. Mancinelli, Peroxides and the Survivability of Microorganisms on the Surface of Mars, *Advanced Space Research*, Vol. 9 No. 6, p. 191, (1989).

17. In a personal conversation, James Murphy suggested bacteria could definitely be spread globally. James R. Murphy, Robert M Haberle, Owen B. Toon, James B. Pollack, Martian Global Dust Storms: Zonally Symmetric Numerical Simulations Including Size-Dependent Particle Transport, *Journal of Geophysical Research*, Vol. 98, No. E2, (1993).

18. McKay and Davis, p. 198.

we are prepared to send humans, and we are not confident about possible contamination effects, we might want to define a restricted area that human activity would be temporarily confined to, especially if we think contamination effects could be global. This is also related to our understanding of how movement will affect the spread of contamination. Should remote reconnaissance of some locale from an established base be done before sending humans out into that targeted area? Again, criteria for determining that any given locale is devoid of life might also be useful to help have confidence regarding the relaxation of procedures for activities in that area.

So, how important is the preservation of extraterrestrial life? How much confidence do we want to have regarding the biological status of any given locale or of the entire planet before possibly jeopardizing indigenous ecosystems with a potentially intrusive human mission? It may be that many could agree a conservative approach is warranted and feasible, but that may not be enough for it to be realized since many forces could conspire to relax such a cautious exploratory approach. If we have some sense for this ahead of time, perhaps a pre-detection policy guideline would suggest the need for many robotic precursor missions.¹⁹

Post-detection guidelines would help guide our activities if and when we discover a possible sign of extraterrestrial life. Should we immediately take a sample for lab analysis, or study it remotely first? Should the sample be sterilized immediately? Some might suggest that we should leave the area completely until we obtain more knowledge of that potential life-form via remote analysis. Will we require a quarantine facility on the surface to study possible life-forms, or will it be safer to send a sample to an orbiting laboratory so as to contain any possible adverse effects? As impractical and extreme as it may sound, others might suggest that we leave the planet entirely, perhaps for ethical reasons, or at least until more is known about the nature of that life and its distribution on the planet. More generally, will we be prepared, technically and politically, to deal with such a discovery in situ? For the first mission, it may not be feasible to send the appropriate technology and facilities to cope with discovering extraterrestrial life. Some may go further

and suggest we leave Mars so that life can be allowed to evolve and flourish without human interference. How rigid would or could such a policy be?

We will not likely be able to resist the temptation of studying such a discovery. We will want to send more missions and establish a robust scientific outpost to study the new life-form(s). Would this eventually lead to a small community as we become more efficient at utilizing the Martian resources? Should potential population growth, either by immigration or reproduction, be controlled so as to avoid jeopardizing the indigenous biota of Mars?

The nature of the life that is discovered will clearly be of critical importance in exploring these difficult issues. More specifically, whether Martian life is found to have had its own independent origin (and hence perhaps quite different from terrestrial life) may be very important regarding how we view that life. If, on the other hand, Martian life is found to belong to the same phylogenetic tree as terrestrial life (via the panspermia hypothesis) then we might be less conservative—although some will argue the scientific, and perhaps ethical, merit of allowing autonomous evolution to occur in substantially different environments from that on earth.

As an example, peaceful co-existence is one long-term option to consider as a thought experiment. Ironically, Richard Taylor's slogan, "Move over microbe!" might apply.²⁰ That is, extraterrestrial microbes might be displaced, as often happens on earth, but they need not be harmed or destroyed. Can we co-exist with Martian life?²¹ Would we combine into one ecosystem? Assuming we were careful, Martian life might not be destroyed. It could, however, change via the forces of its new ecosystem. Or perhaps we will decide to preserve that life in a kind of isolated conservatory, perhaps with the indigenous Martian environment intact, so that, to some approximation, it will be allowed to evolve as it might have otherwise.²² This might be acceptable to

19. Don DeVincenzi notes in an abstract submitted at the Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life (1990) that guidelines from a previous workshop on planetary protection suggest that "human landings are unlikely until it is demonstrated that there is no harmful effect of martian materials."

20. Martyn Fogg notes a radio interview with Richard Taylor. Martyn Fogg, *Terraforming: Engineering Planetary Environments*. SAE International, Warrendale, p. 494 (1995).

21. J. Baird Callicott notes that co-existence may be feasible since we will not have to consume indigenous life as we do on earth. This may true in the near-term, but longer term activities could cause the extinction of indigenous life via indirect effects. J. Baird Callicott, *Moral Considerability and Extraterrestrial Life*. E. C. Hargrove (Ed.), *Beyond Spaceship Earth: Environmental Ethics and the Solar System*. Sierra Club Books, San Francisco, pp. 250-251 (1990).

22. Robert Zubrin opens the door for such a compromise when he suggests that the polar regions will be available for indigenous

many people, although there will certainly be legitimate skepticism.

Although the possibility of discovering extant Martian life may be legitimately perceived by many to be remote, it is nonetheless, wise to be prepared for such a possibility.²³ Policy should be driven not only by the likelihood of an event, but its significance, as well. And addressing these questions now will not be wasted if we were to indeed find a lifeless Mars. This kind of planning can only help prepare us as we move out into the rest of the solar system in search of life.

Underlying many of these questions are issues of value, and policy will ultimately be driven by which values are made the priority. Clearly these are difficult issues—partly because we have so little relevant data, and partly because they are long-term. Nevertheless, exploring these issues now as part of long-term contingency planning is probably wise since there is time to collect the relevant data and seek a healthy international consensus. Once this Human First Detection Policy is established, then GO!

If it is thought that contamination could be global, we must try to *establish the criteria for assessing with an appropriate level of confidence the biological status of the entire planet*. This is will likely turn out to be a very tricky problem, partly because we only have one data point, the terrestrial biosphere, on which to base any criteria. However, it may still be possible to establish criteria that should be satisfied before having some appropriate level confidence about the biological status of Mars. If a few strategic missions are adequate, how many, and of what kind? If many missions are required, the same set of questions hold, with a key long-term question being the total number of missions required since this will be a key schedule driver for a human mission to Mars. Certainly, exploring this kind of planning and criteria now for such long-term activities has the problem of potentially not being applicable in the long run, and hence, perhaps unworthy of our

attention now. Obviously, we should expect that plans and criteria will be modified, perhaps significantly, due to the evolution of our knowledge and unforeseen factors. But thinking about these criteria now will help prepare us for future mission planning. We should try to address the associated issues now to ensure that all preliminary steps are implemented in an efficient manner as we plan our first presence on another planet.²⁴

If only a few strategic missions are required, and precursor robotic exploration doesn't find any signs of life, then establish the Human First Detection Policy, and GO! If signs of extinct or extant life are found, that could imply that the determination that only a few strategic missions would be adequate to assess the biological status of Mars should be called into question. If many missions appear to be required, assess how many and of what kind. If no life is found after completing those missions, establish first Human First Detection Policy, and GO!

If life is found, we should obviously try to understand what the data suggests about its nature. We might want to establish and consult a Robotic First Detection Policy which would presumably be international guidelines on how to respond to a robotic detection. If humans are needed, or more generally, if it is determined that humans should go immediately regardless, then get clear on the Human First Detection Policy, and GO!

If it is decided that humans should not go immediately, we will want to conduct extensive robotic study to understand that life, eliminating, as much as possible, the adverse effects due to many such missions. When the threshold for obtaining as much understanding as is reasonable via robotic exploration is reached, then GO!

For this decision tree, the “no-go” decision branch would be considered effectively final because the decision tree allows for an extended temporary period of time during which a no-go decision would essentially be in effect until there was enough confidence to send a human mission. The no-go conclusion shown on the decision tree would be extreme and would require a compelling justification. Indeed, it should be noted that there may be circumstances which some would see as justification for such an absolute no-go decision. For example, it

life to predominate. Robert Zubrin, *The Terraforming Debate, Mars Underground News*, Vol. 3, pp. 3-4 (1993).

23. Richard Randolph, Margaret Race, and Christopher McKay, in *Reconsidering the Theological and Ethical Implications of Extraterrestrial Life, The Center for Theology and the Natural Sciences* Vol. 17, No. 3, p. 6, (Summer 1997), write: “There is currently no NASA policy, or international protocol, for the proper handling of non-intelligent extraterrestrial life. We believe that such a policy should be developed now, before these discoveries are made. Such a policy would be informed by an ethical analysis concerning our obligations as space explorers.”

24. It is obviously important to consider regional contamination—that is, somewhere between local and global. This will reduce the global biological status problem somewhat, but the fundamental challenges remain.

is conceivable that if Mars is teeming with a very dangerous form of life, a decision could be made to “quarantine” the planet for an indefinite period. However, as indicated above, the more likely scenario under such circumstances is that since humans will want to study those life forms in situ as we do dangerous organisms on earth, we will likely simply take whatever time and action necessary to have confidence about the first mission.

There is, however, another possibility that could lead to a no-go decision. Political and ethical reasons for keeping humans away from Mars could prevail. There will be those who will suggest that Mars is its own world with its own value, and that any indigenous life should be allowed to exist unaltered by human interference, especially in light of our ability to impact environments.

SOME ETHICAL VIEWS

A fundamental underlying question for much of the issues that have been raised is: *How much do we value the preservation of a primitive extraterrestrial life form and why?* There is much to be said in a rigorous treatment of such a question given the great body of work that exists on ethics and value theory. But here will we touch on some rare and recent attempts of a few thinkers who have addressed some ethical issues associated with space exploration.

Certainly there is instrumental value, or more specifically, scientific value associated with ensuring the integrity of extraterrestrial life. Masking the existence of such life and/or destroying it beyond recognition would be an immense scientific loss. However, it isn’t clear that scientific value will be enough to ensure the integrity of that potential data. As history has painfully demonstrated, the momentum of doing a thing, of accomplishing a goal to satisfy needs or desires, often overshadows contemplation of consequences and any potential policy that might result thereof. And looking further ahead, we might also wish to consider how we will guide our actions if and when the scientific novelty wears off.

Applying Standard Ethical Views

As Robert Zubrin points out, an obvious problem for those who would suggest that the human settlement of Mars should not take priority over the ensured existence of extraterrestrial microbes is to provide some explanation as to why such an answer wouldn’t

apply to terrestrial microbes which “we wouldn’t hesitate to kill with an antibiotic pill.”²⁵ This is a reasonable challenge. However, at the same time, it also reasonable to suppose that extraterrestrial microbes should not be viewed the same as terrestrial microbes. Zubrin himself acknowledges their unique value.²⁶ Perhaps more importantly, assuming Martian microbes are of an independent origin, as a species, they would be unique in a way that terrestrial microbes are not. This significant uniqueness might imply a kind or degree of value, instrumental or otherwise, that might not be associated with terrestrial microbes.

Carl Sagan challenges us with his sentiment: “If there is life on Mars, I believe we should do nothing with Mars. Mars then belongs to the Martians, even if they are only microbes.”²⁷ Although the notion of rights is not directly invoked in Sagan’s remark, his suggestion can be associated with a rights based ideology. Similarly, Chris McKay has appealed to an intrinsic value of life principle and hence suggests that Martian microbes have a right to life—“to continue their existence even if their extinction would benefit the biota of Earth.”²⁸

Such rights based views often fall short in demonstrating why life should be considered *intrinsically* valuable and why extraterrestrial microbes would have such an absolute right to life. In general, rights are problematic because they are often seen in degrees when difficult decisions have to be made. Degrees of rights, in the final analysis, ultimately seem no different than degrees of value. Indeed, J. Baird Callicott writes: “The assertion of ‘species rights’ upon analysis appears to be the modern way to express what philosophers call ‘intrinsic value’ on behalf of nonhuman species. Thus the question, ‘Do nonhumans species have a right to exist?’ transposes to the question, ‘Do nonhuman species have intrinsic value?’”²⁹ If one claims that other animals have rights and that there are no degrees of rights, how are we to assess those situations that involve conflict of rights and/or

25. Zubrin, *The Terraforming Debate*, pp. 3-4.

26. Zubrin and Wagner, *The Case For Mars*, p. 135.

27. It’s not clear if this implies we stay off the surface completely, use sterilized robots only, or just prohibit colonization while allowing in situ experimentation via human explorers. Carl Sagan, *Cosmos*. Random House, New York, p. 130 (1980).

28. Chris McKay, Does Mars Have Rights? D. MacNiven (Ed.), *Moral Expertise*. Routledge, London, p. 194 (1990).

29. J. Baird Callicott, On The Intrinsic Value of Nonhuman Species. Bryan Norton (Ed.), *The Preservation of Species*. Princeton University Press, Princeton, p. 163.

interests between humans and other life forms?³⁰ Indeed, for those who think Martian life has rights, a compromise might not be satisfactory. Only a non-interference policy would be acceptable.³¹ However, we might consider Chris McKay's compelling view that the rights of Martian life "confer upon us the obligation to assist it in obtaining global diversity and stability."³²

Steve Gillett has suggested a hybrid view combining anthropocentrism as applied to terrestrial activity combined with biocentrism for worlds with indigenous life.³³ A pluralistic approach to ethics has a practical common sense appeal. Andrew Brennan is critical of moral theory that attempts to encompass the complexity of life under a single principle and hence embraces such an approach to environmental ethics.³⁴

Cosmocentrism

Robert Haynes, Chris McKay, and Don MacNiven have been prompted by the consideration of extraterrestrial activities to suggest the need for a "cosmocentric ethic". They conclude that existing ethical theories exclude the extraterrestrial environment because they are geocentric and cannot be applied to extraterrestrial environments, hence leaving a vacuum for a cosmocentric ethic.³⁵ There may be a deeper instinct being gestured at by these thinkers more akin to sensing deficiencies in existing ethical views in general, not just as they apply to issues of space exploration—although it may be that the new context, or lens of space exploration, has rightly prompted the consideration of new perspectives—for example, a cosmocentric perspective.³⁶

As with environmental ethics, the central issue for a cosmocentric value theory is justifying intrinsic value.³⁷ Indeed, the significance of appealing to the Universe as a basis for an ethical view is that an objective justification of intrinsic value might be realized to the greatest extent possible by basing it on the most compelling objective absolute we know—the Universe. We would also like to have some way of objectively assessing or measuring value.

Holmes Rolston offers a compelling view which appeals to the "formed integrity" of a "projective Universe." This view suggests that the Universe creates objects of formed integrity (e.g. objects worthy of a proper name) which have intrinsic value and which should be respected.³⁸ However, Haynes points out that Rolston's view appears to conflict with modifying the earth, even to the benefit of humans.³⁹ Rolston's view would certainly call for the preservation of primitive extraterrestrial life. Rolston's view also attempts to address the problem of assessing or measuring value by suggesting that if a thing has formed integrity, or is worthy of a proper name, it should be respected. But recognizing formed integrity seems to be the value measurement problem in a different, albeit perhaps more useful, form.

The systemic, interdependent connectedness of ecosystems is often cited as a foundation justifying the value of parts of the larger whole, since a subset contributes to the maintenance of the larger whole. Consider Leopold's egalitarian ecosystem ethic: "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong if it tends to do otherwise."⁴⁰ In *The Ecological Self*, Freya Mathews suggests that intrinsic value can be grounded in self-realization, which is a function of interconnectedness. The Universe qualifies for selfhood and hence self-

30. Deep Ecology views tend to have as a central tenet, biological egalitarianism, according to which all organisms have an equal right to life. See Arne Naess, *Ecology, Community, and Lifestyle: Outline of an Ecosophy*, Cambridge, 1989.

31. Alan Marshall, Ethics and the Extraterrestrial Environment. *Journal of Applied Philosophy* Vol. 10, No. 2, p. 233 (1993).

32. McKay, Does Mars Have Rights? p. 194.

33. Steve Gillett, The Ethics of Terraforming, *Amazing*, pp. 72-74 (August 1992).

34. Andrew Brennan, *Thinking About Nature: An Investigation of Nature, Value, and Ecology*, (1988).

35. Robert Haynes, *Ecopoiesis: Playing God On Mars. Moral Expertise*, p. 177. See also Haynes and McKay, Should We Implant Life On Mars? *Scientific American*, p. 144 (December 1990) and MacNiven's, *Creative Morality*, p. 204. See also, Donald MacNiven, Environmental Ethics and Planetary Engineering, *Journal of the British Interplanetary Society* Vol. 48, pp. 442-443 (1995).

36. Martyn Fogg writes: "the concept of terraforming is inspiring enough to perhaps generate a formal effort toward extending environmental ethics to the cosmic stage." Martyn Fogg, *Terraforming: Engineering Planetary Environments*, p. 490.

For additional discussion see, M. Lupisella and John Logsdon, "Do We Need A Cosmocentric Ethic?" Paper IAA-97-IAA.9.2.09 presented at the 48th Congress of the International Astronautical Federation, Turin, Italy (October 1997).

37. Callicott writes: "In addition to human beings, does nature (or some of nature's parts) have intrinsic value? That is the central theoretical question in environmental ethics." Intrinsic Value in Nature, *The Electronic Journal of Analytic Philosophy*, 3, Spring 1995.

38. Holmes Rolston III, The Preservation of Natural Value in the Solar System, E. C. Hargrove (Ed.), *Beyond Spaceship Earth: Environmental Ethics and the Solar System*, Sierra Club Books, San Francisco, (1990).

39. Haynes, *Playing God on Mars*, p. 177.

40. Aldo Leopold, *A Sand County Almanac*, New York, p. 262, (1966).

realization (again, for which interconnectedness plays a critical role) and humans participate in this cosmic self-realization.⁴¹

Construed cosmically, then, connectedness may hold promise for a cosmocentric ethic. In particular, it may be that connectedness itself is a necessary property of the Universe, and that to actualize connectedness necessarily requires interaction. Such a view might favor maximizing interaction and robust actualizations of connectedness/interaction—perhaps, for example, complexity, creativity, uniqueness, diversity, intensity, etc.—as the foundation of a cosmocentric ethic, since it would contribute to the greatest realization of the nature of the Universe (i.e. its “self-realization”). Indeed, in making choices consistent with this view, humans might help propagate diversity here on earth and throughout the Universe,⁴² but not necessarily at the expense of other robust actualizations of connectedness/interaction (e.g. perhaps other “kinds” of life forms).⁴³ The trick would be to assess relative degrees of value corresponding to degrees of realizing connectedness/interaction.⁴⁴

The Fact-Value Problem

It is important to acknowledge the importance of the fact-value (or “is-ought”) dilemma which suggests, among other things, that knowing something about the way the Universe *is* cannot lead to a justification of value. Thankfully, this complex philosophical problem, although ultimately relevant, is beyond the scope of this paper. But, consider that this problem can also be understood as values not necessarily having to follow from facts—not that values absolutely cannot follow from facts. That is, if we

find a fact-based value theory compelling enough, we have the choice to associate and/or derive value (an “ought”) from what “is”.⁴⁵ Our value theories can be models just like other theories.

The ecologist Frank Golley has argued that activities in space such as the colonization and terraforming of Mars will be unavoidable since it is consistent with the dominant myths and metaphors of western civilization. Historically, these dominant myths and the exploration that results from them have not been concerned about the indigenous systems they effect, including the existence of human beings. Is this the kind of action that is unavoidable? Golley suggests that to turn away from these pursuits would require a fundamental reorientation of our culture.⁴⁶ If a lack of concern for indigenous life-bearing systems is part of our dominant myths and exploratory pursuits, then perhaps a fundamental reorientation of our culture is exactly what’s needed. Ironically perhaps, this would be consistent with Robert Zubrin’s vision of Mars as an opportunity for a “grand noble experiment”—a chance to explore new ways of life. Indeed, we could create a new branch, or branches, of human civilization with all the promise that holds, while at the same time fostering a kind of respect that has often been absent. To a large extent, it’s already happening. This century’s strong environmental and animal rights movements are powerful examples. We need only to extend similar attitudes to extraterrestrial environments.

Finally, some may argue that the rational pursuit of ethics is futile—that rationality is slave to the passions, and that self-interest is the primary motivator of human activity. Certainly, this is partly true. But it is also true that we can be rational and thoughtful regarding what we value and why, especially since human beings are extremely diverse and are motivated by many different forces. Ultimately, through a mix of reductive, creative, and ecological thinking, as favored by Frederick Turner,⁴⁷ we will likely strike a reasonable balance among many diverse forces regarding the status of extraterrestrial life in our policies and worldviews. We need only be proactive and thoughtful.

41. Mathews articulates selfhood and self-realization generally, and in a cosmic sense, in Chapter 3, and the associated ethical implications in Chapter 4 in her book, *The Ecological Self* (1991).

42. Freeman Dyson writes: “Diversity is the great gift which life has brought to our planet and may one day bring to the rest of the Universe. The preservation and fostering of diversity is the great goal which I would like to see embodied in our ethical principles and in our political actions.” *Infinite In All Directions*. New York: Harper & Row, (1988).

43. Indeed, as suggested previously, the kind of life that might exist on Mars could play a critical role in what kind of value is assigned to it. The cosmocentric view suggested here might imply that a unique extraterrestrial life-form be assigned a higher value than primitive terrestrial organisms, since it would constitute a significantly unique universal creation, where, again, creation of new, unique, robust forms of interaction are a necessary part of the Universe’s evolution.

44. I try to articulate the philosophical foundation and implications of such a view in *From Biophysical Cosmology to Cosmocentrism, (SETI In The 21st Century: Cultural and Scientific Aspects*, SETI Australia Centre, January 1998).

45. Callicott claims that Hume’s is/ought dichotomy can be bridged “in Hume’s terms, meeting his own criteria for sound practical argument.” Hume’s Is/Ought Dichotomy and the Relation of Ecology to Leopold’s Land Ethic, *Environmental Ethics*, Vol. 4, (Summer 1982).

46. F. B. Golley, “Environmental Ethics and Extraterrestrial Ecosystems,” *Beyond Spaceship Earth: Environmental Ethics and the Solar System*, ed. E. C. Hargrove, San Francisco, Sierra Club Books, p. 225 (1986).

47. Frederick Turner, *Life On Mars: Cultivating a Planet and Ourselves*, Harper’s Magazine (August 1989).

